S.J.B.

A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

Published at

LOYOLA COLLEGE

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VOL. XVI MARCH, 1939 NO. 3

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EASTERN STATES DIVISION

Vol. XVI. MARCH, 1939 No. 3

SCIENCE AND PHILOSOPHY

THE SCIENTIFIC REPLY TO MODERN SCIENTIFIC ERRORS

REV. THOMAS B. CHETWOOD, S.J.

In the December number of the Bulletin there appears a report of Father Wulf, S.J., on some tenets of modern scientists. He stresses most emphatically the eminence of the propounders of these tenets—some of them Nobel Prize men—and then he urges, in what seems to be the whole aim and purpose of his observations, the lack of orthodox philosophers able to answer these giants of experimental science. I append a paragraph from his report:

> "We must admit that up to the present time no one has appeared whose mastery of mathematics and of experimental science was equal to the task of disproving in argument the false philosophy in question. What is more, there is grave reason to fear that none of our philosophers is able even to understand what these scientists say. For this a specialized training and preparation is required, which our philosophers lack."

Then Father del Pulgar, S.J., adds an unqualified support of Father Wulf's statement with the recommendation that great efforts should be made to train specialists in the great cause of vindicating "the wise and true doctrines of scholasticism."

Let us look at some of the errors explicitly named for us by Father Wulf: "No true, objective certitude about an external world is at all attainable, but only a greater or less degree of probability."

Now, according to Father Wulf, this conclusion has been reached by "professors seeking in their researches only the progress of the sciences and the development of truth through *incontrovertible experiments*" (italics mine). Furthermore it requires "a mastery of mathematics and of experimental science" to disprove this false philosophy.

This statement can mean two things.

First, it can mean that we must master the formulas of mathematics and experimental science in order to trace the erring steps of the eminent professors down to this conclusion. But this is like asking us to study the gibberish of a madman in order to find the clue to his madness. For such stuff which is not even new (as the professors would claim), is the most arrant philosophic madness. The

reality of an external world is part of the reality of objective truth—that is to say truth that is distinct from and antecedent to the perception of it. And the reality of objective truth not only needs no proof but cannot be denied without asserting it in the very denial. When one asserts the proposition 'There is no objective truth', he necessarily asserts the objective truth of the proposition and of the terms which constitute it.

But in the second place, Father Wulf's statement can mean that this refutation would not fit into the formulas of mathematics or of experimental science. Well, then some adjustment is necessary. But the adjustment is needed not on the part of our philosophy but of theirs. Or perhaps it is better to say that the philosophers need adjusting. It is a subtle kind of surgery which is called for—one worthy of a Jesuit's zeal to seek out and find.

Let us take two more instances of this scientific philosophy supplied by Father Wulf. And we beg you to note that, although he said that he fears "that none of our philosophers is able even to understand what these scientists say", still he has been able to translate this much and bring it within reach of our lay intelligence. Our cordial thanks are due Father Wulf.

"Substance—identical with energy—is likewise a mental concept answering to a collection of sensations of some probability."

There is no need of mathematical training to analyse and answer this but rather of skill in identifying the peculiar psychosis of the author and of all those who thoughtfully call it coherent thought. Energy which is fluent or actual must have its ultimate origin in a principle, which is a substance. To account for the origin of energy by a point which, taken precisely, is nothing, is like claiming to pour water from a thoroughly empty bottle. Prestidigitators claim this; but they are playful deceivers.

Finally, we have kept the best for the last,—

"The principle of causality affords a useful theory for researches. However it is only chance that is important in microscopic and ultramicroscopic (atomic) phenomena and causality plays no part."

Here is pitiful ignorance of the meaning of words as well as of pure rational values.

A chance effect is an effect without design, or, without what is technically called a final cause. But a chance effect still demands an efficient cause which is what is alone referred to in the age-old 'Principle of Casuality'. The mathematics of chance is sound enough thinking. If, for instance, one throws a handful of shot against a wall, it is possible to calculate with more or less accuracy the chance which each shot has of coming to rest in a drawn square on the floor. But does such a calculation eliminate all need of accounting for the efficiency that brings the shot to rest there? If that is so, then there are whorls and whirlpools in mathematics which carry the calculator

out of the domain of reason or, better, bring on a dizziness in which reason vanishes.

It is cruel that experimentalism should have to wear the guilt of such mental degeneracy, when there is so much noble human industry for it to be proud of, so many peaks of discovery to its credit.

SCIENTIFIC QUESTIONS RELATED TO PHILOSOPHY

To the Editor of the SCIENCE BULLETIN:

I would like to take this opportunity to congratulate those responsible for the publication in the SCIENCE BULLETIN of "Sundry Documents No. 15" from the 28th General Congregation. It would seem that any one truly interested in the subjects treated therein must agree substantially with the remarks of both Fr. Wulf and Fr. P. del Pulgar.

However the situation may not be quite as black as is painted in paragraph c) p. 50 of Fr. Pulgar's remarks. He says: "So it comes about that among the physico-chemical questions related to philosophy appearing in *programs* so far published we find old disputes with atomists . . . which besides being out of date are wholly lacking in importance philosophically. On the other hand there is *not even a word* about the undulatory conception of matter . . . about transmutation . . . etc., etc." (*italics mine*).

Just for the record I would like to submit the fact that as far back as 1934 a paper was read by Mr. A. V. Shea (now Fr. Shea) on Electron Diffraction, which explained the work of Davisson and Germer, inasmuch as it constituted an experimental proof of the wave properties of matter. This paper was presented at the regular Philosopher's disputation in February as may be verified by consulting the Woodstock files containing programs of such disputations.

Shortly afterwards the presentation of papers of this nature was discontinued at the disputations. However in the course "Scientific Questions connected with Philosophy, from Physics", which has been taught for the last seven years, material on the newly discovered elementary particles, on the conversion of mass into energy, and on nuclear transmutations constitutes a considerable fraction of the syllabus, and the treatment of these subjects may be judged from such articles as the "Neutron" in the current issue of the BULLETIN, as well as: Mass and Matter, Vol. XI p. 127; The Positron, Vol. XIII pp. 140 & 179; Nuclear Disintegration, Vol. XIV p. 180 and The Neutrino, Vol. XV p 71.

JOHN S. O'CONOR, S.J.

PSYCHOLOGY AND BIOLOGY

An outline prepared by Father Joseph A. de Laburu, S.J., Professor of "Quaestiones Scientificae ex Biologia et Anthropologia" at the Gregorian University.

Scientific Questions Connected With Philosophy.

Questions from Biology

Biology is linked with Philosophy in the treatise on Psychology:

1. As a preamble to the study of Psychology. Therefore it should be studied *before* Philosophy, *accurately*, and in a way to embrace the *latest* findings.

   The study includes Cytology, Histology, General Physiology, Human Physiology, especially of the *senses* and the neurohumoral relationship.

2. In the problems of life, precisely as *life* problems:

   a. origin of life—b. evolution—c. finality—d. the vital principle—

   b. forms existing in living things (the problems of life in separated tissues).

3. In Psychic life—

   A. In Animal Psychology:

      a. sensation—b. affection—c. tendency—e. problem of instinct.

   B. In Rational Psychology—

      a. intellectual life—b. volitional life.

   C. In Normal and Abnormal Psychology.

What is indicated under numbers 2 and 3 can be treated in the course "Scientific Questions............"

a. either *all* of it (covering the principal points)

b. or only *some* of the matter treated more extensively.

In the course this year (1938-39), for example, we are treating "Characteriology" because it embraces what is indicated in number 3 above (and also some things from Anthropology). Moreover, this question:

I. has great scientific importance

II. is a live issue (since this is the first year it is taught in scholastic circles and as yet is taught in only a few universities)

III. has practical utility for

a. knowing men

b. directing men

c. correcting men.

NOTE: *The new Ratio Studiorum will probably not advise following the first of the two methods indicated above, namely of covering in the relatively short time alloted (2 or 3 semester-hours) the whole field of contact between Biology and Psychology (per summa capita).*

Rev. Edward C. Phillips, S.J.

VARIOUS VIEWS ON THE SCOPE OF MODERN PHYSICS

Rev. Joseph T. O'Callahan, S.J.

In this article we wish to criticize various attempts to determine the scope of Modern Physics. There are in general, four views of the subject: Physics deals with objective reality, but this objective world is purely mechanistic; Physics does not deal with reality, but with Kantian subjective constructs and mathematical symbols; Physics being a branch of mathematics does not deal with the physical world of cosmology; Physics does deal, though perhaps inadequately, with an objective world, which is not purely mechanistic but is endowed with true qualities. We wish to discuss each of the four views in turn:

Mechanistic Reality:

When reading the works of the older physicists, there is at first a satisfying assurance that the general point of view and attitude of mind is common to reader and writer. From Newton, through the proponents of classical physics, down to the first writing on the "New Physics" the scientist's method of explaining a problem seems quite natural both to the common reader and the philosopher. That apparently acceptable point of view is explicitly and clearly stated by Carhart in his "College Physics", page 1. "In studying the facts of nature we assume the objective reality of physical phenomena and the existence of external objects apart from the mind of the observer. While we become acquainted with the physical universe solely through our senses, it will probably be admitted that every form of matter, such as a pebble, a drop of dew, and the oxygen of the air, has objective existence. From this point of view only two classes of things or entities are found in this physical world—matter and energy". It is clear that, according to this view physics is a science of physical reality, but that the reality is mechanistic; there is no place for qual-

ities. This was of course the common view of the nineteenth century physicist, and its mechanistic interpretation is opposed and refuted in the ordinary cosmology text book. There is no need here of discussing it further.

Kantian Symbolism:

In contrast to this view, it is commonly held today that Physics does not deal with reality. In the New York Times for December 10, 1937 a news account of the symposium held at the Franklin Institute the previous day, was introduced by the headlines: "Physicists Drop World of Reality". "Enthrone abstraction, a Mathematical Ghost". "American Physicists strip world of its last vestiges of reality". Papers were presented at the symposium by E. B. Kemble of Harvard, W. F. G. Swann of the Bartol Research Foundation, J. C. Slater of M. I. T. and E. N. Condon consulting physicist for Westinghouse.

Now, although the reaction of sensation-seeking reporters are not in general trustworthy, yet perusal of the actual papers, shows that in this case the headlines were justified.

From Professor Kemble we have: "The difficulty experienced by the physicist in explaining his work to non-professionals has become much more serious on account of the tendency towards abstractness in the formulation of the physical theory. However there is, I believe, no possibility in reversing the trend towards abstraction in theoretical physics. In the process of developing theories, we have been led to invent abstractions or constructs, not directly items of experience, such as electric and magnetic fields, atoms, electrons, wave functions and dynamical variable matrices. These constructs are the material of our thought and the symbols which appear in the mathematical formulæ which express our rules."

"No one can quarrel with the physicist for the introduction of constructs since everyone must recognize the fact that in the last analysis the world of space, time, things and people in which we conceive ourselves to live is itself an invention which every human being makes instinctively in order to create some order in the moving panorama of experience".

"From the standpoint of commonsense there exist two universes, or worlds, namely, an internal world of perception, thought and emotion, and an external world of space, time and matter, which is assumed to impinge on the internal world. The external world, although in fact a construction, is deemed as real as the internal world".

In this explanation of the divorce of physics from reality, it is clear that the divorce is not founded on scientific reasons, but is based on the Kantian distinction of phenomenon and noumenon. Physics is divorced from reality because all knowledge is divorced from reality; physics is a science of symbolism, where the objective thing

symbolized is as such unknowable, because all objective things are in themselves unknowable and only known when moulded in subjective frames.

This position is made even more clear in the following paragraphs of Professor Kemble's article: "My fundamental point is that the puzzles of the Quantum Theory have originated for the most part in the notion that its constructs are, or should be, reflections of the realities of the external world. I assert that the province of the physicist is not the study of an external world, but a study of a portion of the inner world of experience. Hence there is no need why the constructs introduced need correspond to objective realities".

We have thus a second view of the scope of Modern Physics directly contradictory to the first; according to this view, physics is not a science of objective reality. We make no criticism here of the claim that Modern Theoretical Physics must become highly symbolic. As will be indicated later, the trend towards mathematical symbolism, granting the breakdown of mechanism and the ignorance of scholasticism, was an inevitable refugium. It would be quite legitimate for the physicist to develop the relations between physico-mathematical symbols and, prescinding from the question himself, leave to the philosopher to determine how much objective reality is signified by the symbols. But from the quotations given above it is clear that many eminent physicists do not prescind from the question but give an answer, and the answer is that physics is not dealing with objective reality. While not rejecting the symbolic method, we do reject the conclusions reached by these modern physicists. To justify the rejection it is sufficient to point out that the divorce from reality was a conclusion in no way drawn from physical fact or theory, it is a conclusion that follows solely from the application to physics of Kantian Philosophy. A specific refutation is not required because the standard theses in Epistomology refuting the Kantian doctrine of phenomena apply fully here.

Philosophy as a branch of Mathematics:

There is a third view of the scope of Modern Physics which likewise implies that the subject matter of physics is not the actual physical world. According to this view, Modern Physics is not a science of the actual physical world because it is a branch of mathematics and hence deals with the relations between the "entia rationis" of mathematics.

This is the view expounded by Maritain in several articles. (Confer the long second chapter in his book "The Third Degree of Knowledge"; his paper presented at the last Thomistic Congress in Rome etc.) Maritain's thesis is that Modern Physics is not primarily conducted with reality, but has evolved into a system of mathematical symbolism. This thesis is of course in no way influenced by Kan-

tianism, but it must be rejected because it overlooks the essential distinction between pure and applied mathematics.

According to Maritain, theoretical physics is divorced from reality, because its method is mathematical, and mathematics is admittedly a science of "Entia rationis". Now although Maritain explicitly states that these relations between various entia rationis which make up the body of theoretical physics, all have some "fundamentum in re"; yet his mistake seems to be in identifying this real foundation of theoretical physics with that of pure mathematics. A careful study of pure and applied mathematics shows that there is a decided difference in the fundamenta. We must now establish that distinction which makes Maritain's position untenable.

Briefly the difference between the two sciences is this: theoretical physics incorporates in the problem actual physical data, whereas no physical data is incorporated in any purely mathematical problem. This difference must be elaborated in greater detail.

First consider pure mathematics. It is true of course that the original concepts with which we start our mathematical reasoning were derived from observation of the material world, according to the axiom "nil in intellectu quod non prius fuit in sensu." But the mathematician makes an immediate precision from all physical actuality, and relations between his abstractions are deduced. In pure mathematics the number 2 is treated as no more or no less real than the number square root of minus 2. For the mathematician, the conclusions of Euclidean and Non-Euclidean geometry both prescind from physical verification; they are merely conclusions drawn from two different but self consistent systems of postulates. Throughout his whole field, the pure mathematician is in the realm of pure possibles; he deals with relations between pure possibles. To such an extent is this true, that the mathematician needs only the knowledge of his own existence, as the basis in actuality of the whole mathematical system. The axiom "nil in intellectu nisi quod prius fuit in sensu" can at least theoretically for the mathematician have this minimum content. Strictly speaking he needs no data from the senses about the external world. From the single concept of his own existence he can derive the concept of oneness; now he has two concepts; and reflecting on these two he derives the concept of the relation between the two and has the concept of relations. He can proceed and build up his whole world of mathematical analysis. Bertrand Russell can be an idealist and a pure mathematician without inconsistency, because the pure mathematician deals exclusively in the realm of the pure possibles, his science is totally unconcerned with actual reality.

The theoretical physicist, on the other hand, does not roam through the field of pure possibles; he always confines himself to the physically possible. By physically possible is meant reality that can exist in the physical world, compatibly (i.e. in sensu composito) with

the original data which, from the outset of the investigation, is assumed as existing in the actual physical order. Here is the essential difference between applied and pure mathematics, the difference between the physically possible and the pure possible. Pure possibility merely implies compatibility of notes contained in the concept, physical possibility implies not only compatibility of notes but also simultaneous compatibility with some actually existing reality; the extension of the pure, therefore far exceeds the extension of the physically possible. Conversely, the comprehension of any concept pertaining to theoretical physics, as such, is far greater than that of any purely mathematical concept.

The starting point of theoretical physics is the data of observation. This physical data is from the outset incorporated in the problem, hence the problem is not one of pure mathematics. Never prescinding from this data, but always assuming it as existing in the physical world; one then prescinds from any other unknown factors that may have influence on the physical effect but which were not included in the data. By the use of mathematics various relations are found to exist between these refined data.

For example, assume the Newtonian laws of motion as physical laws based on observation, the theoretical physicist can deduce what the path of a body would be if it were attracted by another with a magnitude inversely proportional to the second power of the distance. He can always deduce what the path would be if the bodies attract inversely to the fifth power of the distance. The conclusions are both physically possible, in the exact sense as defined above.

After this purely deductive process one turns again to experiment to check the theoretical conclusions, i. e. to find whether the conclusion which is now known to be physically possible is also a physical actuality. In the example cited above, it is found by observation that the interaction of bodies is such as it would be according to the inverse square law. We conclude that bodies in the physical world actually do attract each other according to this relation. No such check with objective reality is found for inverse fifth power attraction, and we conclude that in the actual physical world no such relation exists. Nevertheless the theoretical conclusion still remains and always will remain physically possible, i. e. possible in the world as governed by the laws of motion. Not only are the notes of fifth power attraction compatible in themselves, they are simultaneously compatible with the actual Newtonian physical laws of motion. In contrast to this a purely mathematical conclusion need not be compatible with any physical law, rather, as such, i.e. in as far as it is purely mathematical, it is merely compatible in itself, i.e. has self consistent notes.

The laws spoken of here are definitely determined relations, and the example shows that there are three different types of relations involved.

By a long process of induction it is found that the inverse law of attraction for all bodies is valid in the actual order. The law enuntiates an actual relation between actuals. A universal inverse fifth power attraction of bodies is not of course simultaneously possible, but it is simultaneously compatible with some known physical actuality, i.e. a world actually moving with the relation of Newton's three laws of motion, could be a world of inverse fifth attraction. Hence inverse fifth attraction is known to be physically possible. The "law" thus gives a possible relation between actuals inadequately known.

In contrast to this, a purely mathematical conclusion (or law) e.g. propositions of Euclidean geometry, need not be compatible with any known physical actuality; indeed in as far as it is pure mathematics derived from arbitrary axioms, the proposition is not known to be in agreement with physical actuality. The mathematical proposition as such enuntiates a relation between possibles. Now a possible relation between actuals has an essentially greater foundation in physical actuality than the foundation supporting the pure possibles, hence the science of Theoretical Physics must be essentially different from the science of Pure Mathematics. But Maritain has reached his conclusion that modern physics is not primarily concerned with the actual physical world, by neglecting this essential distinction. With the distinction established, Maritain's position is untenable.

Scholastic View of Scope of Physics.

In the ordinary Cosmology text book, it is assumed that the positive sciences, and physics in particular, do, de facto, treat of physical reality. It is pointed out that physics, though differing in its formal object, has the same material object as Cosmology, and Cosmology certainly treats of the actual physical world. That this is the correct description of the relation between the two sciences is not in itself obvious, and is nowhere explicitly proven. Philosophers seem to arrive at their opinion by assuming that modern physics is the same in scope as the old natural philosophy. Now though there exists a physical world as an apt subject for a non-philosophical science, it does not necessarily follow that modern physics is such a science, even though this physics is evolved from a natural philosophy which did have the same material object as cosmology.

The original Natural philosophy, like the physics of Aristotle and the Middle Ages, did certainly treat of objective reality. Basing his discussions on simple sense observations (and assuming that these have objective validity) the natural philosopher strove to discover the objective character of the physical bodies. Of course his intellectual discussion, his thoughts, were as all thoughts must be, subjective acts; but the thought content was assumed to be objective and hence his discussion was always concerned with objective reality. It is important to notice that his observations were largely concerned with

qualities, and that his discussion assumed that he had a knowledge of specific qualities.

In contrast to the old natural philosopher, the modern physicist who developes quantitive physics as an exact science completely neglects all qualities. Convinced that we do not have a knowledge of specific qualities, he goes further and denies the knowledge of, or the need for any qualities. When the classical physicist of the nineteenth century claimed that objective reality was the subject matter of his science; he was referring to an external world denuded of all these qualities, genetic and specific, the existence of which the scholastic insists on. For the ordinary physicist, objective reality meant mechanistic reality and when physics developed in the twentieth century in such a way that its subject matter was definitely not mechanistic, then it seemed to follow that its subject matter could not be objective reality. With the door to objectivity apparently closed to physics, there is left to the physicist, mathematical symbolism, with admitted ignorance of the real objects that are signified, or an appeal to Kantianism, for the complete divorce between all knowledge and reality. With the conviction of Cartesian mechanism deeply rooted in the scientific mind, and completely intertwined with all classical scientific theories, it does not occur to the physicist that a non-mechanistic world, a world endowed with qualities might exist and be subject matter of physics.

The scholastic has a philosophical system which can direct the physicist out of his maze, but the scholastic must take care not to exaggerate his knowledge of qualities. There is a great difference between knowledge of qualities and the knowledge pertaining to extension e.g. magnitude, position, motion. With the initial abstraction from the phantasm, we have specific notions of extension so that for example we foretell exactly what will be the result of adding a length of five feet to a length of three feet. We have not this specific knowledge of qualities e.g. the color red. Indeed we do not have an exact knowledge of any generic quality e.g. color. Abstraction from the phantasm gives us only the higher generic concept of "qualitas patibilis" and implies little more than the possibility of intrinsic change. Confer Hoenan S. J. "Cosmologia" Gregorian Press 1936 #109.4 "Nec ipsum genus coloris tali modo (ac extensio) perceptum nobis est plane pervium; quidem genus suuperius in quo convenit color cum sono, videtur, per solam abstractionem a phantasmate, nobis esse vere notum; et hoc genus superius est: qualitas patibilis".

But for the problem in hand, this very generic notion of quality suffices. It tells us that the bodies are capable of intrinsic change, and that intrinsic change will be the important objective counterpart of the extrinsic change which is exactly measured by the physicist. For the theoretical explanation of how qualities are capable of mathematical measurement confer Hoenan pages 185-204.

The procedure of the physicist may be described thus: There exists an external world, bodies with quantities and qualities. Direct knowledge of specific qualities is impossible; direct knowledge of quantities is inescapable. The physical facts of the physicist are a true but partial picture of reality; without denying intrinsic change, the physicist may concentrate on the quantitative aspect and on the extrinsic changes involved in the process. From the sense data the physicist selects only that which can be measured by a meter stick, a watch or a balance. These primary scientific facts have true, but inadequate objective validity, but in no way deny the objective existence of qualities, indeed logically involve the existence of at least generic qualities.

The mechanist is wrong in claiming that the bare "scientific fact" is an adequate reflection of the actual physical world, the scientific Kantianist is wrong in claiming that they are not supposed to be reflections of an external world, and Maritain is wrong in claiming that because these "scientific facts" are amenable to mathematical treatment, they thereby cease to be reflections of the actual external world.

ASTRONOMY

TOTAL ECLIPSE OF THE MOON, NOVEMBER 7, 1938

REV. THOMAS D. BARRY, S.J.

On the late afternoon of November 7, there was visible in the Eastern United States a total eclipse of the moon, which was widely heralded in the newspapers as having this peculiarity, that both the sun and the moon would be above the horizon at the beginning of the eclipse. This apparent anomaly was due to the fact that, although the sun was really below the horizon, atmospheric refraction would make it appear above.

The eclipse was observed at Weston by Father James Connolly and myself. The day had been quite cloudy, but during the afternoon the clouds thinned out considerably. At the time of the beginning of totality, 4:45 P.M., E.S.T., there were only a few thin clouds, except along the horizon, where there was still a bank heavy enough to obscure the beginning of the eclipse. Shortly before 5 o'clock the moon emerged from the clouds already in eclipse. The color of the moon did not differ much from that of other eclipses, but the western half of the moon was considerably darker than the other side. This was probably due to heavy clouds on one side of the earth interfering with the light rays which would normally be refracted toward the moon. Our main purpose in watching the eclipse was to observe the occultation of a seventh magnitude star. It was this program which brought to light another phenomenon of the eclipse, which apparently had not been predicted anywhere. When we located the star in our telescopes, we discovered another, brighter star north of it and in line with the advancing moon. The predicted star was occulted at 5:42:31, and about eight minutes later the unknown also disappeared behind the moon. A little investigation then showed that the extra star was the planet Uranus! Thus we had witnessed the rare phenomenon of the occultation of a planet during a total eclipse of the moon. The *American Ephemeris* and the British *Nautical Almanac* include planets in their predictions for occultations, but they do not predict for a day or so before and after full moon. Apparently they did not consider the possibility of occulations during total eclipses, and neglected to predict that of Uranus. Father Connolly also observed the emersion of the star at 6:38:47.

BIOLOGY

THE RATE OF PULSATION AND THE FUNCTION OF THE CONTRACTILE VACUOLE IN PARAMECIUM MULTIMICRONUCLEATUM

Rev. John A. Frisch, S.J.

(Abstract)

I. Relation Between Feeding and the Rate of Pulsation of the Contractile Vacuoles

In mass cultures of Paramecium multimicronucleatum, observed daily for 20 to 30 days, simultaneous observation of the rate of pulsation and of the rate of feeding revealed that the average rate of pulsation and the average rate of feeding varied from day to day; but that usually the rate of pulsation varied directly with the rate of feeding, increasing or decreasing from day to day as the rate of feeding increased or decreased. The size of the food vacuoles and of the contractile vacuoles varied with the age of the culture, so that the numerical relation in seconds between the rate of pulsation and the rate of feeding at any particular time depends upon the relative sizes of the food vacuoles and of the contractile vacuoles. The results indicate that variations in the rate of pulsation are due to variations in the rate of feeding, and suggest that the effect of many experimental factors on the rate of pulsation is probably indirect, i.e., they affect the rate of feeding.

II. Relation Between Locomotion and the Rate of Pulsation of the Contractile Vacuoles

In vaseline enclosures from 1 hour to 30 days old, the rate of pulsation of the contractile vacuoles was lower in active than in resting individuals of Paramecium multimicronucleatum; the magnitude of the difference depended upon the kind and the extent of the locomotion. 'Spasmodic movements,' a few seconds in duration, either decreased or increased the rate of pulsation. 'Crawling,' or locomotion, usually in contact with the substratum, between neighboring masses of food, and sometimes for longer distances, decreased the rate and sometimes stopped pulsation. Swimming on a spiral path over relatively long distances greatly decreased the rate and usually stop-

ped pulsation instantly. Observation showed that the relation between locomotion and the rate of pulsation is indirect, i.e., the pulsations decrease in rate or stop during locomotion because feeding decreases or stops during locomotion. Observation also showed that there is a constant absorption of water from the oesophagus during the formation of the food vacuoles, and also when no food vacuoles are being formed; and that this absorption may be interrupted during locomotion. The results indicate that there is no endosmosis of water through the pellicle, and that all the water expelled by the contractile vacuoles enters the animal with the food vacuoles and by adsorption from the oesophagus.

III. Relation Between Feeding and the Relative Rate of Pulsation of the Anterior and Posterior Contractile Vacuoles

In flourishing cultures of Paramecium multimicronucleatum the rate of pulsation of the posterior contractile vacuole was higher than than of the anterior vacuole in approximately 90% of the individuals observed. This percentage was decreased to 70 in depleted cultures, to 60 in toxic cultures, to 57 and 45 in individuals in the 3 and 4 vacuole stage of fission respectively, and to 0 in non-feeding individuals. The results indicate that the relative rate of pulsation of the anterior and posterior contractile vacuole depends upon the extent and the rate of feeding.

CHEMISTRY

RECENT ADVANCES IN CHEMISTRY

Rev. Richard B. Schmitt, S.J.

The march of science proceeds as relentlessly as time and tide in this the twentieth century. During the past year, there was much progress in pure science and tremendous progress in industry, due almost entirely to intensive research. The United States and England are now leading the world in scientific research; and it is quite safe to say, that because of other interests, three European countries have retrogressed considerably, and these countries were the outstanding contributors to science for many years.

A brief resume of the outstanding advances in chemistry during 1938 may be of interest. The subject is so large and varied that it is impossible to record all progress; we wish to mention only what is most important in pure research and in industrial chemistry.

Sub-atomic structure is still a subject of investigation in many research laboratories. Several large cyclotrons were recently constructed and results are gradually appearing in the literature. — The properties of helium at extremely low temperatures are strange, it acts as if it were more fluid than any normal gas and passes through the walls of the container. The physical and chemical properties of atoms under extreme pressures also show remarkable changes. By specially constructed apparatus pressures have ranged from 300,000 pounds to the square inch, to 2,000,000 pounds to the square inch. In one laboratory, a method has been devised by which a temperature will be reached that is within .001 degrees of Absolute. — Dr. Harold C. Urey has planned a method for obtaining heavy carbon, which will be a great help in observing the course of nutritional substances through the body. — Carbohydrates were produced on the surface of pure nickel oxide when it is irradiated with white light in the presence of carbon dioxide. — The detection of spectral lines of the ninety-third element were reported in minerals containing uranium. — The x-ray diffraction characteristics of over a thousand chemicals were tabulated and classified. It is expected that this method of analysis will come into more general use because it is easy and rapid.

New organic chemicals are finding varied uses in medicine. Sulfanilamide is finding more varied applications than ever. Its most

recent use is in the treatment of blindness from trachoma. Sulfanilamide very probably has a direct action on the infecting bacteria. New derivatives of this compound are being prepared and found effective in pneumonia. — Many new vitamins have been reported, and several others have been prepared synthetically in pure crystalline form. Three different laboratories, in three different countries, have successfully synthesized vitamin E. — After seven years of carefully planned research the Rockefeller Institute has prepared a vaccine against yellow fever. Because of the war in China, ephedrine is now prepared synthetically; ephedrine is: α methylamino—α —ethyl benzyl alcohol.

The growth of industrial research is phenomenal, and at the same time profitable. In the United States in 1938, it is estimated that one hundred and eighty millions of dollars were spent on industrial research. The personnel of the industrial laboratories has increased from six thousand in 1920, to approximately forty-four thousand in 1938; and there are approximately one thousand and seven hundred laboratories in operation. Rather complete lists of the new industrial products may be found in: Industrial and Engineering Chemistry, industrial and news edition. These cover a wide and varied field of chemical research in the technologies of cellulose, petroleum, pharmaceuticals, electro-chemical processes, agriculture and food chemistry.

Several new synthetic fibres were perfected and are ready for large scale manufacture: v.g. nylon, which is extremely tough, elastic and uniform. Synthetic wool is now made from casien. Another artificial fiber, the Hofa thread is produced in Germany from wood fibre stock; also viscose is used as a substitute for jute and ramie. The Ford Motor Co., produced a fiber from the proteins of the soybean. Gold plated fibers are made in England to be used for dress goods. By this new process a film of gold can be deposited on the fiber less than 0.0001 inch thick. The fiber is dipped in an organic gold compound, slightly heated and the gold is deposited on the fabric like a dye. The gold dyed cloth will sell for about two dollars and fifty cents a yard.

In 1900 our country was dependent upon imports for its potash, and now there is sufficient for our own needs, and a surplus for exportation. — Carbon dioxide gas is used for the presenvation of certain fruits.—Pure glycerol is synthesized from petroleum gases.—A better cellophane is now made which does not deteriorate by water. Synthetic resins have found many new uses: reflectors of lucite are made to make night driving more safe; surgical splints have been made of transparent lucite, which enable x-ray photographs to be made without removing the supporting appliances.—Magnesite is now made from sea-water and oyster shells. (A substitute for plaster of Paris.)

On electrolytic process is now used for coloring the surfaces of metals without the use of pigments. The color produced is a function of the plating time; and all colors are produced in one plating bath. —Quartz coils or springs are now being used for extremely accurate weighing.—A quick drying cement has been prepared which will set completely in four hours; a practical application for military and construction and in flood areas.—A thin invisible coating of beryllium is put on the surfaces of silver in order to prevent tarnish.

This very brief survey will indicate the practical results of industrial research. There are many new research laboratories in construction from coast to coast. The Federal Government is building four regional research laboratories for the United States Department of Agriculture, at the cost of four millions of dollars.

CHEMISTRY MARCHES ON.

PHYSICS

THE NEUTRON

Its Discovery and Nature

REV. JOHN S. O'CONOR, S.J.

Before 1920 theorizers on atomic structure seemed to be satisfied with the two particles (proton and electron) which had been presented to them by the experimentalists. However in the above mentioned year Rutherford in his Bakerian lecture indicated that he hoped a search for the element of atomic number zero would prove fruitful. This was more than mere speculation, for in his own laboratory and through the insight of one of his coworkers and former students the existence of the neutron was established twelve years later.

Because of its fundamental part in the constitution of nuclei we will consider in this article the nature of the neutron and the experiments which led up to the conclusion that there is a particle in nature which possesses no charge and has a mass equal to that of the proton.

As early as 1920 Rutherford had shown the possibility of disintegrating nitrogen by the bombardment of that gas with alpha particles, and before 1932 transmutation of all the light elements from boron to potassium (with the exception of oxygen and carbon) had been accomplished. Such transmutation was recognized from the ranges of the disintegration products,—as studied with the aid of scintillation screens, Geiger counters and especially cloud chambers. The most commonly observed reaction was of the type

$$_{z}M^{A} + \alpha \longrightarrow {}_{z+1}M^{A+3} + p$$

However when beryllium was bombarded by alpha particles from polonium several workers found what appeared at the time to be a very penetrating radiation emanating from the target. From the low absorption coefficient in lead (0.22) Bethe, Backer and the Curie-Joliots estimated that this radiation was a gamma ray photon of about 7 Mev, which was excited after capture of the alpha ray by the Be nucleus. However the Joliots, using an ionization chamber to examine this same radiation noted that the slight ionization, resulting from the apparent radiation, increased considerably when material containing hydrogen was placed between the target and ionization chamber. These workers suggested that the penetrating radia-

tion from the Be was ejecting protons from the hydrogenous material (paraffin or cellophane) by a process similar to the Compton effect, and in fact Chadwick found particles projected as far as 40 air cms. in the forward direction.

Since the specific ionization of the projected atom was identical with that of the proton there seemed little doubt concerning the nature of this secondary particle. On the basis of the Compton effect formula:

$$E_{max_p} = \frac{2h\nu_o}{2 + mc^2 h\nu_o},$$

the energy of a gamma ray necessary for the projection of a proton with a range of 40 air cms. (5.7 Mev) was 55 Mev.

Chadwick, at the Cavendish laboratories, continued and extended this investigation; substituting in addition to hydrogen, lithium, carbon, helium and air between the Be target and the ionization chamber. He also found that in addition to the identity in specific ionization between the projected hydrogen particle and protons, the particles from the other elements gave increasing ionization with increasing charge and mass, leading to the conclusion that in each case the ion producer was a recoil nucleus of the material of the secondary target.

The first difficulty perceived by Chadwick was the fact that the available energy from the capture excitation of the alpha particle by the Be nucleus, in the reaction postulated by the Joliots

$$({}_4Be^9 + \alpha \longrightarrow {}_6C^{13} + \gamma),$$

is only of the order of 15 Mev while the postulated gamma ray required for the observed projection of the proton is 55 Mev. The former value is obtained from the K.E. of the incident alpha particle which for Po is 5 Mev plus the difference in binding energy between Be^9 and C^{13}. This can not exceed 10 Mev, since the mass defect of C^{13} is itself only of this order of magnitude.

Thus the postulated reaction leaves 40 Mev of supposed gamma ray energy unaccounted for. Chadwick went further than this. He compared the energy of the recoil atoms from hydrogen with those of nitrogen, and from the relative masses of the two atoms showed that if the postulated gamma ray of 55 Mev could give an energy of 5.7 Mev to a proton, the maximum it could give to a nitrogen nucleus was about ½ Mev (actually 400,000) which meant an air range of only 1.3 mm. and a total of 10 to 13 thousand ion pairs; whereas ranges of over 3 mm. and total ionization of from 30 to 40 thousand pairs were found for nitrogen recoil nuclei.

These values of range and ionization for the projected nitrogen nuclei meant that they had received an energy as high as 1.2 Mev, and to receive this amount from a Compton encounter would require a gamma ray of 90 Mev. Thus either energy was not conserved in

these processes or an arbitrary selective gamma ray of different energy for each recoil nucleus would have to be postulated. (In addition, gamma rays of such high energies should produce recoil electrons of several air meters in range. A systematic search for them revealed none.)

Chadwick appreciating all these difficulties saw that they would be entirely eliminated if the supposed radiation from the beryllium were considered rather to consist of particles of zero charge and mass of unity (on the scale of Oxygen = 16); and he proceeded to show how the required quantitative relations were satisfied if the projection of the protons and other recoil nuclei was accomplished by such particles rather than by quantum radiation.

The neutron, as the particle was then called, was considered as released from the struck Be nucleus after capture of the alpha particle. The reaction is thus indicated: ${}_4Be^9 + \alpha \rightarrow {}_6C^{12} + {}_0n^1$

From the classical formula for elastic collisions the maximum velocity with which a particle at rest may be projected forward by a "head on" collision with another moving particle is given by:

$$V_r = \frac{2M_n}{M_n + M_r} V_n$$

Here the subscripts r indicate the struck nucleus (initially at rest), while the subscripts n indicate the neutron; M standing for mass and V for velocity.

From the two cases which Chadwick used (hydrogen and nitrogen) the velocities of the recoil nuclei (p and N) were determined from their ranges to be respectively 3.3×10^9 and 4.7×10^8 cm./sec.

Therefore $$V(r_p) = \frac{2M}{M_n + 1} V_n \quad \text{and} \quad V(r_N) = \frac{2M}{M_n + 14} V_n$$

Hence $$\frac{M_n + 14}{M_n + 1} = \frac{3.3 \times 10^9}{4.7 \times 10} \text{ or } M_n = 1.15 \pm 10\%$$

Taking therefore M_n roughly as unity, V_n was found to be 3.3×10^9 cm. sec,— indicating an energy of emission of the neutron from the carbon nucleus of not greater than 8 Mev.

The more exact evaluation of the mass of the neutron was later obtained from other disintegration processes; the following being an example of the same. The reaction: ${}_5B^{11} + \alpha \rightarrow {}_7N^{14} + {}_0n^1$ gives neutrons which project protons from hydrogenous material with a maximum air range of 6 cms, yielding a velocity of 2.5×10^6 cms/sec. or an energy of 0.0035 mass units.

We may write on the principle of the conservation of mass and energy:

$$M_{B^{11}} + M\alpha + KE\alpha = M_{N^{14}} + M_{n^1} + KE_{N^{14}} + KE_{n^1}$$

The masses of boron nucleus and alpha particle are known from mass

spectograph data on boron and helium; the energy of the charged particles from ranges of the same in cloud chamber and absorption experiments, while the neutron energy is measured from the maximum range of the "knock-on" protons, which receive the entire energy of the neutron when they participate in a "head on" collision with a particle of the same mass. Thus with all quantities in the above equation known, with the exception of the neutron mass, a solution for this latter is obtained,—giving (on the scale of oxygen — 16) a mass to the neutron of between 1.005 and 1.009.

Since, as we have seen, neutrons possess no charge they produce scarcely any ionization; theory and experiment agreeing that not more than one ion pair is produced for a neutron air range of two or three meters.

They are however most effective projectiles for nuclear disintegration; having no charge there is no ordinary coulomb force of repulsion between them and the positively charged nuclei.

Not long after the discovery of the neutron Fermi and his collaborators found that when neutrons were slowed down by passing them through paraffin, water or other hydrogenous material their apparent capture cross section increased enormously. (The slowing down process is due to elastic collision with the protons of the surrounding material and because of the practically identical mass energy exchanges are so rapid that the neutrons have their velocities reduced to a value such that they are in thermal equilibrium with the medium of velocity reduction after passage through 5 or 6 cm.,—when that medium consists of paraffin.)

In many cases the resulting nucleus, after capture of the slow neutron and the emission of a gamma ray, becomes artifically radioactive and in other cases the neutrons are simply captured and the nucleus settles down to a stable isotope of the original one, with the emission of a gamma ray.

The efficiency of this capture process varies from element to element in the most capricious way. For example Ag. has an effective capture cross section of 55×10^{-24} cm^2; Cd. one of 3000×10^{-24}. Again neutrons of one velocity will result in capture and subsequent radioactivity for one element while producing scarcely any effect on another, while another neutron group with slightly different velocity will produce artificial radioactivity in the element unaffected by the neutrons with velocities which affect the first mentioned element.

This selective absorption of slow neutrons of different velocities by given nuclei has been interpreted by Bohr as a resonance effect of the neutrons with a virtual energy level of the compound nucleus. When the neutron has an energy coinciding with one of the resonance levels there will be a large probability of its capture.

The accepted theory of the nature of the neutron to-day is that it does not consist of a proton and electron in close association but

that there is really only one heavy elementary particle; the proton and neutron being two different inner quantum states of the same.

Thus all nuclei are considered to be made up of protons and neutrons, and electrons as such do not exist in the nucleus. Not only does this theory explain the statistics and spin of most nuclei but it overcomes several serious difficulties inherent in the postulation of electrons inside the nucleus, viz:—The magnetic moments of nuclei are of the wrong order of magnitude (as experimentally determined) on the supposition that electrons exist in the nucleus; the wavelength of the electrons (of energies found from beta ray emission) is much larger than the nuclear radius; it is theoretically impossible to devise a potential barrier which would keep the electrons inside the nucleus.

The forces existing between elementary particles are considered to be of the exchange type; similar to that elaborated by London and Heitler for the binding of the atoms of the hydrogen molecule. While the ordinary Coulomb force of repulsion exists between proton and proton, this must be small compared to the exchange force between proton and neutron. The reasonableness of this conclusion can be seen from the stability and abundance of elements whose nuclei must be held together by such a force (proton-neutron). For nearly one-half of the material of the earth's crust is oxygen which consists of eight pairs of protons and neutrons; next in abundance is silicon with 14 pairs of protons and neutrons, while the most stable of all nuclei is the alpha particle consisting of two pairs of protons and neutrons. On the other hand while the deuteron (one pair of proton-neutron) exists, no particles of mass 2 and charge 0 (neutron-neutron pair) nor of mass 2 charge 2 (Heilum 2, proton-proton pair) have ever been found.

The question might well be asked: Just as the change in the mass of the electron with its velocity, its materialization from gamma ray energy and its converse dematerialization, as well as its wave characteristics and indeterminacy with regard to position and momentum have all been used as arguments showing that the mass of the electron is entirely electromagnetic in nature, so now can not the existence of the neutron, a supposedly elementary particle of *no* charge, be used as an argument in favor of the position that certainly all mass (and matter) is not electromagnetic in nature? The argument seems to be sound except for one point; the apparent necessity of postulating a magnetic moment for the neutron.

Since the magnetic moment of the proton is approximately 3 nuclear magnetons, and that of the deuteron approximately one nuclear magneton we have no choice except to conclude that the magnetic moment of the neutron should be the difference between these two or -2 nuclear magnetons. (This necessity is not absolute as is indicated by Gamow (Atomic nuclei and Nuclear Transformations p. 60-62) since it is possible that the deuteron be in P or D

rather than in an S state).

Dunning and others have attempted to measure the magnetic moment of the neutron experimentally by a method which is a modification of the Stern-Gerlach experiment, and while the results so far have not been conclusive, a real effect due to the moment has been found.

Unless we can explain away this magnetic moment of the neutron our argument for the *non*-electromagnetic nature of mass from this source can not be conclusive, since the only way we can account for a magnetic moment on classical electromagnetic theory is by the presence of a moving electric charge.

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Note: *This was intended as the last of series of articles on the number and nature of the elementary particles, but due to the advent of the "mesotron" (Nature 142,* 878, 1938) *it is hoped that a further note on this particle of "intermediate mass' may be added in a later issue of the Bulletin.*

THE SUPERMICROSCOPE

REV. BERNARD A. FIEKERS, S.J.

"Natur und Kultur", a Catholic scientific monthly for the nonprofessional man, carries an interesting article on the "Uebermikkroskop". (N. u. K., *35*, 328—339, Okt. 1938; 22 illustrations; Herold Verlag, Solln vor München)

What we will call the "supermicroscope" claims a two thousand percent step-up in the performances of its predecessors. Such an advance in any technical or scientific instrument is noteworthy. But it is of special interest to us when the case is that of the microscope. For the microscope is entwined in our own earliest scientific traditions through the work of Fr. Athanasius Kircher S.J.; during the

past three centuries, the microscope has been practically at the forefront of scientific advance; the microscope comes somehow at times into that field of vision that parallels our philosophic considerations of sense perception, our theories on the constitution of matter, our speculations as to the limits of scientific observation; and in the popular mind at least, the microscope has enshrined itself as a very symbol for the spirit of science.

But does two thousand percent bespeak the true advance that has been made? Yes and no! For in principle the new instrument is more electronic than optical. Certain new features have entered the field in consequence, and certain old features have not kept pace.

The supermicroscope is the application of the cathode ray oscillograph to optical problems. The rays are not of light, but of electrons; the medium is not atmospheric, such as optics allow, but of necessity vacuum; the lenses are not optical, but electro-magnetic; the problems of microscope technique are not those traditional in microscopy, but either new ones or those of more adapted nature; the very field of vision is not of light and color, but of light and shadow, —photographic, negative or positive, or on a fluorescent screen; with much resemblance to the X-ray, for its construction is based on almost identical principles. The differences bespeak no straight line advance in the field of microscopy, but rather a compromise that bids fair to send microscopy into new channels—whose last advantages only the historian of tomorrow can pen.

Developed at the suggestion of B. v. Borries and *E.* Ruska (Z. für Phys., *87,* 580, 1934), the supermicroscope has been built in Germany at the Siemens Halska Laboratories (Wiss. Veröff. aus d. Siemens-werken, *17,* 99, 1933). The instrument, mounted on a pedestal about the height of a library table is said to have a height of about two and a half meters overall. The instrument gives the appearance of a complicated astronomical telescope in vertical position. The source of electrons is at the very top. Then comes an enclosed stage for the object. About one third the way down the first electromagnetic lens is built in. At about the half way mark eyepieces are built into the cylinder for comparatively lowpower observation and the adjustment of the object into the highpower field. Then comes another set of electromagnetic lenses. And at the very base of the instrument is a plate chamber. Just above this chamber, four more eyepieces are built into the cylinder as above at the halfway mark.

John Stephen Kestler in his "Physiologia Kircheriana Experimentalis" (Amsterdam, 1680; p. 121) describes one of the earliest glimpses into the "SMIKROSKOP" that is probably on record. He refers to Kircher and seems to be quoting from his works. "For who could believe", he says, "that vinegar and milk abound in such an infinite number of animalculae? And yet in recent times the art of "smicroscopy" has taught us that to the great astonishment of

all.—not long ago I discovered that the leaves of the liburnum and the mastich tree are replete with vermin and that all genera of herbs are but the twinings of marvellously divers filaments—You will find the various fruits, roots, leaves and seeds of different species to be of different form." And then he continues and describes all the micro-animals to be observed—bulls, horses, dogs, etc.,—squintingly, three centuries ago at the cradle of microscopy, much like the freshman of today who tries to distinguish the phases of mitosis before he has learned to keep both eyes open. Then come some very interesting and confirmed observations: "the color differences inherent in the various natural bodies, the blood of the fevered and many other observations as yet unknown to the physicians, and of which he has not even thought."

Mutatis mutandis, we stand at a similar threshold today. For since the supermicroscope is comparatively new, relatively little or nothing has been discovered with it. In the illustrations of the article cited above, the magnified pictures of certain pus germs are compared at 1000 X (optic and stained) with a 20,400 X (electronic and unstained.) Undefined pictures of diphtheria bacillae at 1000 X (optical method) are sharply defined at 18,900 X (electronic method). The bacteria, so to speak, "scrutantur renes et corda". Differences that could once be recognized only pathologically are now morphologically confirmed with the newer instrument. Viruses can now be photographed, and small colloids and makromolecules of the order of $1x10^{-5}$ mm. are now brought into the range of comfortable vision.

This is indeed a tremendous advance. Still, it is an advance that has left many an allied science in arrears, and one that works not without theoretical and practical difficulties on its own front. Not everything is an apt object for the supermicroscope. Thick objects and glass slides would almost completely absorb the electron rays. Therefore thin collodion slides are used. The examination of living objects and those in liquid media seems to be impractical. For heat is evolved in the object, and Brownian movement sets limits to the magnification of such materials. The fact that the "stage" and the plate chamber are in vacuum calls for new technique. The electric applications alone call for specialized training in the operator that will surpass that of an Xray specialist perhaps. The whole science of microscopic staining has fallen a victim to the new principles, for color transmission is out of the question. In its place, a new field may probably be opened—the study of mass distribution in living bodies. One very practical difficulty is the maintenance of constant high voltage in the electromagnetic lenses. For their focusing power is a function of voltage.

It is difficult to visualize the substitution of the new microscope for the old as a secondary instrument in physics, astronomy and allied sciences. The world may envy our five meter astronomical re-

flector in America. And there seems to be no immediate danger of its having to be relegated to some scientific museum.

A twentyfold increase in magnification is undoubtedly a triumph. Some related fields seem to be incapable of equal advance. But others will certainly be opened for the benefit of the whole of science.

NOTE

Georgetown Physics Department

Most of the extensive alterations necessary because of the establishment of the research department have been completed. Two private laboratories have been provided. Work has been progressing in the making of an all-metal oil-diffusion pump, and in the construction of slits and the slit holders for the infra-red spectrometer. It may be of interest to note the very great difference in prices for grinding concave mirrors, of 10 cm. aperture, and 80 to 100 cm. radius of curvature. The lowest price was $7.00 from an optician in Baltimore. (One was actually ground, but the curvature was not even close to the required curvature, due no doubt, to a lack of knowledge of our terminology). The lens grinder at Hopkins will charge $20.00 and a large scientific firm asks $150.00 for the same work. We hope later to have something to report on the working of the new pump.

T. J. L., S.J.

HOW MUCH WORK IS DONE BY A WATCH?

There are few people who reflect on the amount of work done each day by a watch.

A single one of its wheels makes each day about half a million rotations, more precisely 432,000. If these rotations could be spread out in a straight line they would reach a distance of about 11,000 meters (close to 7 miles). Hence in a year there are 157,768,000 rotations. This is an enormous activity for such a small and delicate mechanism! and it has to be performed without the assistance of even a single drop of oil. The watch goes on functioning uninterruptedly despite the habitual carelessness with which it is treated, and it does not demand any attention for long periods of time. But so much

labor performed without lubrication uses it up badly and when finally from exhaustion its mechanism stops still it will be nearly ruined, and even if not ruined it will have become unduly worn out. Furthermore this wheel, whilst making so many motions, must keep on making exactly 2,880 rotations every 9 minutes and 36 seconds, not a single rotation more nor less, if the watch is to keep accurate time. An excess or defect of a single rotation in that period of time means that the watch will gain or lose a whole minute each day.

To keep your watch in the best condition, wind it regularly every 24 hours: do not open it, and much less touch its mechanism. Once a year, if it is a wrist-watch, and once every two years if it is a pocket-watch, have it completely dismounted for a general cleaning and lubrication.

(Extract from an advertisement of a Roman Jewelry Firm.)

E. C. P., S.J.

A PROBLEM IN ELECTRIC WIRING

The Answer

In the December number of the *Bulletin*, Father Edward C. Phillips presented a simple problem in electric wiring, as found on pages 81 and 82. It was most gratifying to receive so many correct answers. Solutions came from many States, and one from Europe.

However, most of the plans that we received overlooked the fact which was explicitly stated in these words:

"To increase the number of locations without increasing the number either of the wires in the circuit or of the indicator bulbs, and without undue complications in the switch system."

The solution as presented by Father Phillips is as follows:

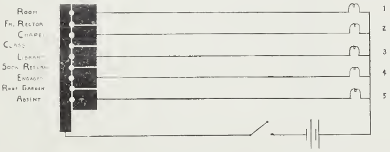

Fig. 1. Rev. John S. O'Conor, S.J., and others.

Drill four new holes so that the plug will engage two adjacent individual switch terminals instead of only one.

The porter's indicator chart reads as follows:

Lamp	*Means*	*Lamps*	*Means*
1	In Room	1 & 2	With Fr. Rector
2	In the Chapel	2 & 3	In Classroom
3	In the Library	3 & 4	Soon return
4	Engaged	4 & 5	Roof Garden
5	Absent		

Other solutions received were more complicated:

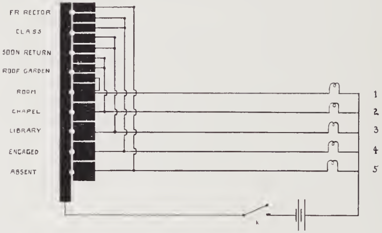

Fig. 2. Rev. Wm. G. Perry, S.J., and others.

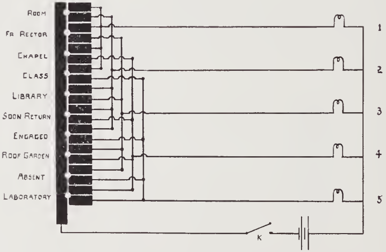

Fig. 3. Rev. W. J. Smith, S.J., and others.

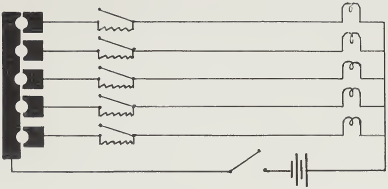

Fig. 4. Rev. T. J. Love, S.J.

Switch open: light dim; switch closed: light bright.

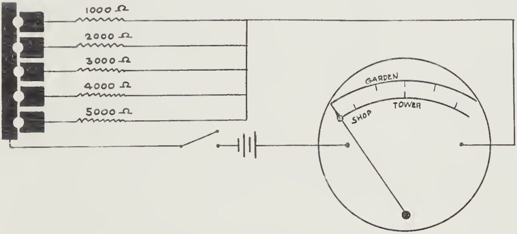

Fig. 5. Rev. F. W. Sohon, S.J. OHMMETER

If meter reads to 100,000 ohms, divisions may be made in steps of of 10,000 ohms.

THE EDITOR.

GEOGRAPHY

THE DEMARCATION LINE CONTROVERSY

Pablo Guzman Rivas, S.J.

The documents on the famous dispute of the 15th century over the Demarcation Line of 1493 are available (1) and since they touch in great part geographical and geodetical matters, they may have some scientific-historical value today. Our readers who wield verniers and micro-this-and-that, and are unhappy in the possession of seven decimal places, may find the dispute interesting and even amusing. The controversy stirred the geographers of the period, and must certainly have aroused renewed interest in explorations and mathematical geography in an age already remarkable for the men who raced through the high seas in their small caravels. In this controversy, explorers and navigators clashed on such points as the determination of longitude, the length of a degree, the location of geographical landmarks, the ownership of the Moluccas, cosmography, etc.

The legal phase of the controversy, and the bitter rivalries attendant on such a partition of lands greatly coveted by many royal dynasties, have been the main concern of historians. On the scientific questions implicated in the demarcation, however, some monographs have been written.

The Demarcation was a serious matter. Portugal and Spain placed all their hopes for further aggrandizement on the outcome of the discussions concerning it. An error of a few degrees placed treasures beyond their reach. So the division required precision, but the means then available for that were inadequate. That is why a question which would be settled now with all the niceties of technique, engendered bitterness and protracted discussions fluctuating between sober scientific opinions and amusing quibbles.

Pope Alexander VI had, in 1493, liberally divided the world and given it to Spain and Portugal as field for further exploration. The Bull was amended the following year by the Treaty of Tordesillas, which placed the line 370 leagues, instead of only 100 as first provided for in the Bulls (2), W. of Cape Verde Islands. All lands east of the Line were to belong to Portugal, while Spain received the western half. Naturally, such a vague provision led to many difficulties, which were in 1524 threshed out in a specially convened Junta at Badajoz, where the technical questions relating to the precise determination of

the divisional line were taken up. On the settlement of these difficulties rested mainly the disputed ownership of the Moluccas. (3)

Today we can see why difficulties should arise at the time the Junta met. The use of the magnetic needle was familiar, and through the efforts of the Navigator, Prince Henry, there were available tables of the declination of the sun. Improved astro labes supplanted cross-staves; the latitude was easy to determine, but the longitude was elusive. (4)

Sea charts were very incorrectly plotted. It was, for all that, a period remarkable for its cosmographers, and for a Ptolemaic revival which greatly stirred the navigators of the day. (5)

II

The Bulls and the subsequent Tordesillas treaty called for a Line 370 leagues west of the Cabo Verde Islands. In order that the Line drawn be straight, caravels were to meet at the Grand Canary Is., which were to be the base for the work at sea (actually however, the line crossed Brazil), which the demarcation necessarily entailed. The "pilots, astrologers, sailors", were instructed to "jointly study and examine to better advantage the sea courses, winds and the degrees of the sun or of north latitude", before laying out the Demarcation Line. But the first difficulty was a fundamental one. Where were the Verde Islands, in terms of the usual coordinates?

The Cape Verde Islands were known to exist from the time Ca Da Mosto found them in a voyage in 1454. Only five islands are mentioned in the documents. There are ten in all in the crescent-shaped archipelago, now known to be between 22° 40′ and 25° 22′ W. long. (Greenwich), or an interval of 2° 42′. In the first charts which the Portuguese presented before the Junta, the Islands were located as follows:

Santiago Island, 5-1/4 degrees
La Sal and Boa Vista (taken on the same meridian) 4 degrees
San Nicolas, 5-1/2 degrees
San Anton, 8 degrees
} W. of Cape Verde.

Thus they placed the group within 4 degrees of longitude. On the authority of Don Hernando Colon, Fray Duran and Cano, the Spaniards corrected the figures and placed the group within 3-1/3 degrees of longitude. Taking the longitude of C. Verde as 17° 33′ W. Greenwich, the charts of 1524 located the Islands between 25° 33′ and 21° 33′ W. Greenwich.

A further difficulty arose when it was seen that the Treaty did not say which island would be the starting point for the measurement, westward, of 370 degrees. Surely, as the Portuguese contended, the starting point was not from *all* the Islands, but from a "meridian where several islands are found, e.g., either from La Sal or Buena Vista". The Castilian deputies disagreed and proposed the island of

San Anton instead, the most westerly of the group. Both evidently wanted to be sure that the Line would put the Spice Islands on their hemisphere.

The next point taken up was the location of the much coveted Spice Islands themselves. The Moluccas, taken in a wider sense to include several distinct groups, are now located between 2° 43′ N., 8° 23′ S. lat., and 124° 22′ - 135° E. long. (Greenw.). The Banda group was known in the 16th century for excellent cloves and nutmeg. The Spice Islands were placed by the Spaniards within "two degrees on each side of the equinoctial", and 150° W. of the Divisional Line.

The Portuguese endeavored to show that the Eastward route to the Malucos was shorter than was currently believed, while the Spaniards presented a series of memoranda and testimonies proving the contrary. They subsequently agreed to bring into the argument a blank globe, in order to locate on it some continental landmarks. They hoped that perhaps they would thus "prove to whom the Malucos belong no matter how the line be drawn." Backed by the testimonies of navigators and pilots, the Spaniards showed their main westward routes in a chart, together with the following points:

> Cape of S. Agustin, in Brazil, 8° S. lat., 20° W. long., from San Antonio, C. Verde Islands.
>
> Strait of Maluccs (i.e., Magellan), with entrance at 52-1/2° lat., 4-1/2° long., farther west (i.e., 24-1/2° from S. Antonio).
>
> Maluco Islands (Gilolo, Tincor, Burnel, etc.) located "in two degrees on each side of the equinoctial, and lying a distance of one hundred and seventy degrees from the meridian of the Cape of San Agustin and one hundred and fifty from the divisional line."

These figures however did not conform with a second chart submitted by the Portuguese, who argued that it was not sufficient that the Spaniards should appeal to authority and say "it was the navigation of Captain Juan Sebastian del Cano" (6). If the Castilian chart were correct, then the Portuguese would have to sail eastwards over 215° of longitude to arrive at the Spice Islands. And yet *their* map showed the Islands to be only 134° away.

The following were plotted on the Portuguese map:

> Cape Verde, Cape Bojador (in Rio de Oro, W. Africa), 13-1/2 deg. from C. Verde.
>
> An islet, La Ascension (8° S. Lat., 14° W. Long.), "and then nothing to C. Buena Esperanza, which was a northwest direction with a north and south distance of 52-1/2 deg., and a run of 60 degrees".
>
> A nameless bay.
>
> C. Guardafui (in the Italian Somliland), "whither it was navigated from Buena Esperanza to the northeast, with

a north and south distance of 50-1/2 deg., and a run of 56 degrees."

Cape Comerin (at the tip of India), "whither it was navigated from Guardafui in an east and west direction, 1/2° northwest, 5° east, and a run of 20°."

To Zamatra (Sumatra), and "up to the point called Ganispola, a run of 15-1/2°, from which point to the Malucos it was 27°".

When the two globes were measured eastwards, the Spaniards showed that there were 183° from La Sal (C. Verde Islands) to the Malucos; in the opposite direction they measured 177°. Eastwards, the Portuguese measured on their globe an interval of only 137°, a difference of 46°. When Colon again took up the cudgels for the Spanish side, he emphasized this discrepancy and accused his opponents of using maps where voyages and true distances could not be ascertained.

In proof of this assertion, Colon mentioned voyages undertaken eastwards by well-known navigators, and the fact that their records showed distances greater than those given by the Portuguese deputies. In the *Itinerario Portugallensium*, the distance from Lisbon to Calicut is reckoned as 3,800 leagues, or 15,000 miles, while from Calicut to *Zamatra* (Sumatra) was a 3 mos. voyage. Santisteban, a Genoese, was reported as having sailed from Adem to Calicut in 30 days, and the 1,400 leagues between Calicut and Sumatra in 83 days. "With this number agree Marco Paulo and Juan de Mandevilla (John Mandeville) in the self-same voyages and travels made by them, as is stated very diffusely in their books." And to bring the gold to build the Temple, Colon continued, King Solomon's ships traveled for 3 years from Ofir and Zetin.

An argument according to "geometrical reasoning", was now offered by Colon to prove the Spanish ownership of the Moluccas. The Lands in question had been located on a sphere, and when "placed on a plane surface, and the number of degrees reckoned by equinoctial degrees (the lands) are not in their proper location", for, as he said, "it is well known in cosmography that a lesser number of leagues along parallels other than the equinoctial, occupy a greater quantity of degrees". Most of the lands along the route from Cabo Verde to the Moluccas were along parallels other than the equinoctial. Therefore, he concluded it would "take a much greater number of degrees when they are transferred and drawn on the spherical body".

"Calculating by geometrical proportion, with the arc and chord, whereby we pass from a plane to a spherical surface, so that each parallel is just so much less as its distance from the equinoctial is increased, the number of degrees in the said maps is much greater . . . and consequently (the Spice Islands) . . . fall . . . inside their Majesties' limits".

"In order to verify the above we must examine the itineraries and navigation routes, and the angles and intersections made by the routes with the meridians and parallels encountered, which are styled angles *positionis* among cosmographers. This is the most certain method of determining lands on a spherical body, when calculating them from the plane surface . . ." Thus Colon deduced the distance from Cabo Verde Islands to the Moluccas as 184° eastwards.

III

Four methods for the determination of longitude were proposed by the Portuguese at the Junta.

2. On land, by taking distances from the moon to some fixed star, as might be agreed upon.
2. By distances of the moon and the sun in their risings and settings, and "this upon land having its horizon above the water".
3. By taking a degree of "the sky without any limit for sea and land".
4. By lunar eclipses.

These appeared formidable and a venture in mathematical geography, which, however, the Spaniards rejected suspecting that the opponents were merely trying to delay matters.

Instead, it was Colon's opinion, the solution of the difficulty depended on the measurement of the sphere of the earth and the length of a degree. But the first was, in his own words, difficult and arbitrary, "unless measurements were always made by line", and this was dismaying to Colon. " . . . we hear and say continually such and such leagues are very long, while others speak of them as small, each one judging according to his own opinion, and taking into consideration the time and rapidity it took him to walk them". Measurement at sea was, it seemed to Colon, more hopeless, because of obstacles, such as "currents, tides, the ship's loss of speed, heavy winds, etc."

"One may be deceived by the ship's burden and bulk; or by reason of the ship's bottom being cleaner or dirtier at one time than another; or whether it is towed or sailing alone; or whether it carries new and old sails, and whether they are of good or ill pattern, and wet or dry; whether the day's run is estimated from the poop, prow or amidships and other special considerations that I pass by, such as heaviness or lightness of the winds, the difference in compasses, etc."

No appeal could be made to the work of predecessors, as he pointed out the diversity of results formerly attained. Aristotle had observed 800 stadia to a degree, making the terrestrial circumference 12,500 leagues; Eratosthenes, 700 stadia, and a circumference of 7,875 leagues, while a more recent calculation of Fray Juan de Pecan, gave 14 leagues and 2/3 of a mile to a degree, and a circumference of 5,100 leagues.

To settle the difficulty once and for all, Colon advised sending an expedition and "select persons and instruments" to compute the needed facts. (After all, the proposed "astrological" methods of the Portuguese were not altogether rejected). In case the expedition did not achieve satisfactory results, they would perforce have to accept what could be found about the size of degrees from tables, almanacs, and "daily calculations of stars".

IV

It is interesting to note the opinions rendered on the subject by Fray Tomas Duran, Sebastian Caboto and Juan Vespucci. First, it is said, the Junta must conform to the measurement of the sailors of the time, who assigned 17-1/2 leagues to "each heavenly degree", or to what that "most grave and practical astrologer Ptolemaeus" calculated, viz., 62-1/2 miles to each degree.

Cabot, Vespucci and Duran proposed that the Line be marked at "twenty-two degrees and almost nine miles" W. of San Antonio Island, or 32 degrees, reckoning from C. Verde. Relying on Ptolemaeus who "makes a distance of one hundred and eighty degrees from the Canarias to Catigara or the Metropol of the Chinese", and subtracting the 32 degrees distance of the divisional line W. of C. Verde, they concluded that the Line passed on the other side of the world "through the mouth of the River Ganges, which lies in one hundred and fifty degrees of longitude. Therefore Malaca, Zamatra and Maluco fall within the demarcation of His Majesty". Ptolemaeus threw them off in their calculations!

So much for this interesting controversy. How closely the arguments conformed to true geography, the reader will discover if he consults a map showing the explorations and trade routes of the 15th and 16th centuries, where the Line is placed between 44° and 45° W. long., (Greenw.), and see where the line cuts the East Indies. Who were right, the Portuguese or the Spaniards?

REFERENCES.

(1) Blair and Robertson. The Philippine Islands (1493-1803). A. H. Clark and Co. 1903. Quotations taken from the documents in vol. i (1493-1529).

(2) Our facts are collated from the documents in Blair and Robertson. Cf Cath. Encyclopedia, s. "Portugal", "Spain", where the Treaty of Tordesillas is mentioned as establishing the Line 360 leagues W. of C. Verde Is.

(3) Whatever Magellan actually accomplished as a result of his voyage, and whatever was decided upon in the Junta of Badajoz did not, however, mean anything, because Charles was led in 1529, for various reasons, to sell his claim to, and trade rights with, the Moluccas. Provisionally, too, an agreement was had between Portugal and Spain to establish a second limiting line 17° on the

equator, 297 leagues E. of the Moluccas, subject to correction if another more accurate determination of longitude were found.

(4) A contemporary writer had said: " . . . (the determination of longitude) is too tedious for seamen, since it requireth a deep knwledge of astronomy . . . ." cf. Brit. Encycl., s. Navigation.

(5) Seaports of Catalonia and Italy were the great cartographic centers. Amcngst the well known cartographers were de Cesanis, Giroldi, Cadamosto, Roselli, Fra Mauro.

(6) Juan Sebastian del Cano, a Biscayan, was in command of the Vittoria, the only ship of Magellan which actually circumnavigated the world.

HISTORY

A MODERN DEFENSE OF ATHANASIUS KIRCHER, S.J.

JOSEPH A. MARTUS, S.J.

During the past mid-winter there appeared in the Worcester Sunday Telegram (Sunday Supplement) a full page syndicated article on Athanasius Kircher, S.J., the famous Jesuit priest-scientist of the 17th Century. Signed by Edwin Misurell, the article was captioned: "An 'Edison' Three Hundred Years Ahead of His Time—A Forgotten 17th Century Genius Discovered Air-condition, 'Movies', Play-Pianos, Periscopes and Amplifiers." The author then went on to give some biographical details of the early part of Kircher's life, saying: "Kircher was born, says an unknown biographer, in 1601 in a tiny German hamlet. His father was a prosperous farmer, so Athanasius was sent to a good school where he immediately showed great interest in the meager science courses offered to students in those days." Following this, the author described, in the well-known popular scientific manner, some of Kircher's discoveries and scientific inventions.

It was Prof. Irving T. McDonald of Holy Cross College who read this article in the Worcester Telegram and who communicated with the Managing Editor concerning the very obvious biographical errors. On the suggestion of the editor, Prof. McDonald wrote a corrective article and was accorded the same prominence in publication that the first article obtained. The Telegram introduced the article as follows: "Some weeks ago, in Section Six of the Sunday Telegram, we printed a story about Athanasius Kircher which Mr. Irving T. McDonald, Librarian at Holy Cross, felt did something less than justice to that great Jesuit scientist. We therefore welcome Mr. McDonald's own account of the career of one of the most extraordinary men of the 17th century."

Prof. McDonald pointed out that Kircher's father was a Doctor of Philosophy and a Doctor of Theology and, although a layman, was professor of theology at the Benedictine House of Studies at Seligenstadt, Germany. Furthermore, without any necessity of referring to "unknown" biographers, there are several "known" biographers, including Laugenmantel, Pfaff and P. A. Brischar, not to mention Kircher's Autobiography translated from Latin into German in 1901, which rather dissipates the forgotten obscurity in which Kircher was supposed to languish. The most curious part of the syndicated article

was the omission of any reference to Kircher being a priest or a Jesuit, though an old print accompanying the article had the legend "Athanasius Kircher of Fulda, of the Society of Jesus".

Concerning Fr. Kircher's scientific discoveries, Prof. McDonald wrote: "Had Thomas A. Edison lived 300 years ago, he might be 'as unknown today as Athanasius Kircher.' Such is the suggestion made by the writer of a syndicated article which recently appeared in numerous American newspapers. Kircher, one gathers from the article, was an unsung mechanical genius whose curious experiments in the natural sciences anticipated the achievements of 20th century inventors, and whose story is only now 'revealed by rare old documents recently found in obscure German archives.' Kircher is far from being the forgotten man. No history of science that is worthy of the name fails to refer to him with due consideration and respect; and no record of the intellectual achievement of the Society of Jesus is complete without mention of one of its most brilliant exponents. Athanasius Kircher was no freak of scientific precocity . . . He was one of the soundest and most versatile scholars who ever lived. His retentive memory and uncommon powers of observation made him particularly proficient in the languages and in the physical sciences, and soon after the completion of his philosophical studies he was assigned to teach these branches at the Jesuit colleges in Coblenz and Heiligenstadt. He was ordained priest in his 27th year and a few months later called to the chair of ethics and mathematics at the University of Wurzburg. In conjunction with the labors imposed upon him by this new assignment, he found time to teach the Syrian and Hebrew languages. During these years Kircher reveled in the opportunities to make first-hand investigations of natural phenomena which had been held inexplicable by men of learning. Among other things he sought to discover the subterranean powers responsible for the volcanic eruptions of Etna and Stromboli, and when Italy was terrified by the eruption of Vesuvius in 1630, Kircher resolved to include that manifestation in the scope of his researches. He traveled to Naples, climbed Vesuvius and entered the very crater of the volcano by means of ropes, making exact measurements of the crater and its inner structure."

Prof. McDonald also wrote to the King Features Syndicate which had originally sent out the article on Fr. Kircher. He pointed out that the article "unfortunately produced an unfavorable impression among the Jesuits at Holy Cross, and probably among the Catholic clergy and laity wherever it appeared." This company replied with thanks for the criticism, regret for the errors and promised to send out Prof. McDonald's article to all newspapers who had received the first syndicated article.

In the meantime the Columbia Broadcasting System had inserted an advertisement in the magazine Fortune whose opening sentence

began: "A curiously imaginative fellow by name of Athanasius Kircher . . ." The advertisement continued with a description of "Herr" Kircher's 'Broadcasting System in the 17th Century'. Accompanied by illustrations of giant trumpets which constituted Kircher's loudspeakers, the advertisement commented as follows: "This dramatic device helped make the entire idea very mysterious and supernatural to 17th century listeners. The principles of sound transmission and amplification did the rest."

Prof. McDonald took up the pen once more, this time in a letter to Pres. Paley of the C. B. S., saying that the advertisement had "produced an impression which I believe you would want to know about." The particular points at issue was the absence of a more definite identification of Kircher, the allusion to him as "Herr Kircher" and to the phrase "and supernatural" in the reference to the device Kircher had invented. He added that the references could have been more diplomatically conceived and more graciously expressed; furthermore that Kircher was a Jesuit and not an obscure and forgotten scientist, but one of the most distinguished scholars ever produced by the Society of Jesus and founder of the Museum Kircherianum in Rome. In a return letter, Mr. Paley expressed thanks for the corrections and announced that they would be brought to the immediate attention of Columbia's sales promotion director. The latter, Mr. Victor M. Ratner, soon wrote, expressing apology for the error in the advertisement, saying: "We already have printed a large edition of the attached brochure, for further distribution of this story. Fortunately your letter arrived in time to catch it before it was mailed out. We will scrap this edition, so that we may reprint it with such changes in the text as will be satisfactory." In the opening sentence of the brochure a change was made from "A curiously imaginative fellow by name of Athanasius Kircher . . . " to "A notable Jesuit priest and scholar by name of Athanasius Kircher . . . " Further "Herr" Kircher was substituted by "Athanasius Kircher." The phrase "and supernatural" in regard to the effect of the trumpets upon 17th century listeners was stricken out.

In conclusion, we must acknowledge to Prof. McDonald a sincere debt of gratitude for championing the cause of one of our own greatest Jesuit scientists so ably and so graciously. To him also we must offer a high meed of praise and admiration for his alertness in detecting those egregious errors and the despatch with which he brought them to the notice of the proper authorities. Finally we must applaud him for his vigorous example of Catholic action and the manner in which he defended the just fame of a Catholic priest and scientist —simply, truthfully, courteously. In all his communications his only aim was that "the truth may appear" and not that he "may seem to have the upper hand." The effect on the press was the instantaneous retraction of all errors, coupled with a humble gratitude for his exposition of Catholic historical truth.

NEWS ITEMS

NATIONAL MEETING OF JESUIT SCIENTISTS

The fourth annual meeting of the National Association of Jesuit Scientists was held on December 28, 1938, at the Cathedral School-Hall, Richmond, Virginia. Representatives of five provinces attended the meeting: New England Province, Maryland-New York Province, New Orleans Province, Missouri Province and Chicago Province.

The presiding officer was Rev. Richard B. Schmitt, S.J., Loyola College, Baltimore, Maryland, assisted by the secretary, Rev. Emeran J. Kolkmeyer, S.J., Canisius College, Buffalo, New York.

The topics for discussion included:

Report on the Science Conventions of the various provinces during the year.

Report on the Research Work in our colleges and universities.

National Science Convention as part of the Centenary Celebration: a) Committee for general plans; b) Committee for program of sectional meetings.

The History of Science in the American Assistancy for the Centenary Number of the Bulletin of the A.A.J.S.

National Science Bulletin.

Science and Philosophy.

Copies of the minutes of this meeting were mailed to the Reverend Fathers Provincial, and to the Reverend Rectors of the colleges and universities in the United States, through the office of the National Secretary of Jesuit Education.

At the election of officers, Father Schmitt and Father Kolkmeyer were again chosen to preside at the next meeting in Columbus, Ohio.

FORDHAM UNIVERSITY: Department of Physics and Geophysics

1) The Eastern Section of the Seismological Society of America will meet at Fordham in May or June.
2) Lectures to be given by the Department:

Feb. 23:—Westchester Teachers Association
"Seismology" — Fr. Lynch

Feb. 27:—Hudson County Engineers
"Engineering and Seismology" — Fr. Lynch

Mar. 3:—Brooklyn Institute

"Modern Seismology"	Fr. Lynch

May 10:—N.Y.U. Chapter of Sigma Chi

(American Museum of Natural History)

"Some Problems in Seismology"	Fr. Lynch

3) Summer Courses are announced as follows:

Cosmic Rays	Dr. Hess
Electricity and Magnetism	Fr. Lynch
Introduction to Theoretical Physics	Fr. Lynch
Vector Analysis	Mr. Hurley
Analytical Mechanics	Mr. Hurley

4) International Union of Geodesy and Geophysics.

Fr. Lynch has been appointed New York Chairman of the Entertainment Committee for the 1939 meeting in September.

FORDHAM UNIVERSITY. Department of Biology

The addition of Bacteriology to our courses has made a favorable impression on the students.

The department was represented at the A.A.A.S. convention by Father Assmuth, S.J., Dr. Forbes and Mr. Dwyer. Father Assmuth also attended the C.R.T.S. meeting.

The Mendel Club is having a very interesting year, each meeting a student member presents a paper which always excites lively discussion.

Our student N.Y.A. taxidermist just completed a mount of a doe head presented to the department.

LOYOLA COLLEGE, Baltimore, Maryland. Chemistry Department

The first meeting of the second semester of the Loyola Chemists' Club was held on Tuesday, February 14th, in the chemistry Lecture-hall. A most instructive lecture was delivered by Dr. Walter A. Patrick, D.Sc., of The Johns Hopkins University, on the subject: "Silica Gel and Its Applications." The lecture was illustrated with moving pictures.

BOSTON COLLEGE. Physics Department

The Physics Library has the complete sets bound and current of all the journals published by the American Institute of Physics.

On February 1st the Physics Department was host to the Physics Research Academy. The advanced undergraduate courses and the graduate courses given this year were explained by Fr. Tobin. These courses were then discussed for their value as a preparation for research work.

On March 4th the Eastern Association of Physics Teachers will be the guests of the Physics Department at their annual meeting. Our lecture rooms, laboratories and library will be open for inspection all day. The faculty here will give teaching demonstrations in Electronics and Atomic Physics.

Dr. Hans Reinheimmer, who measured the spark spectrum of Rubidium at University of Bonn, has been photographing and measuring spectra in the graduate work here.

BOSTON COLLEGE. Physiology Department

The physiology department is carrying on several projects. One of these is the construction of apparatus for stroboscopic study of ciliary motion. Another is the construction of apparatus for stimulating excitable tissues at frequencies ranging from a few, to several thousand discharges per second. The study of the effects of Acetylcholine on the musculature of various invertebrates is also being made.

The frogs in our laboratories are not doing well this winter. They are kept in a moist container, under the same conditions as during the warm weather, but many have died. Change of environment has not seemed to have made any difference.

A recent gift of half a dozen aquaria has led to a vigorous search for cement that will prevent leaks. All available kinds have been tried, but without much success as yet. Does anyone know of any infallible remedy? Suggestions on these two points would be welcomed.

HOLY CROSS COLLEGE. Physics Department

The department has just recently received a gift from the Ford Motor Company—a Ford "cut-away" display engine, 1938 model. It carries a truck transmission with an extra forward speed, all open for inspection, and offering an excellent demonstration of the use of gears. In fact the "cut-away" of all the various parts has been done in expert fashion, and with this as demonstration apparatus, the explanation of the internal combustion engine becomes an easy task.

In preparation for the Mid-Year examination, a special review course for Freshman Mathematics was offered as optional. The class convened for six periods, sessions being held from three thirty to five thirty in the afternoon. Of the two hundred odd students taking Freshman Mathematics, about one hundred and twenty attended.

WESTON COLLEGE. Seismological Observatory

An article by Mr. James J. Devlin, S.J., recently appeared in the October issue of the Bulletin of the Seismological Society of America. Reprints may be obtained by writing the author.

Fr. Daniel Linehan, S.J., read a paper at the December meeting of the Geological Society of America at the Waldorf-Astoria in New York City. The paper was concerned with the occurrence of earthquakes in the New England area.

A joint conference was conducted on February 14th by Prof. Marland Billings and Fr. Linehan at a meeting of the Harvard Geological Society at Harvard University. Prof. Billings treated of the geology of the Mascoma Quadrangle, New Hampshire, and Fr. Linehan explained the seismic methods used in determining the structure contours in one of the basins of the quadrangle. The seismic work was performed last summer as a joint expedition of Weston College and the Harvard Geophysical Committee. The geological survey was made two years ago by Prof. Billings of Harvard University and Prof. Carleton C. Chapman of the University of Illinois.

The Department of Seismology recently received a panel truck from Mr. James Burke, of Boston. The truck will be used for housing and carrying instruments in field work.

Fr. Linehan was appointed the representative of the U. S. Coast and Geodetic Survey in seismology for the New England region.

Mr. L. C. Langguth has been conducting experiments on photographic registration of temperature changes in the seismic vault. These measurements are in connection with a problem on long period disturbances which he has been studying for the past year.

An earthquake in Alaska in November gave us the largest amplitude we have yet recorded on the Benioff equipment. The galvanometer coil turned half way round within its armature and stuck there. The amplitude, therefore, of the light spot would be somewheres beyond Infinity. (sic)

The recent earthquake so destructive in Chile was observed by a member of the department during its recording, some twelve minutes after it took place in South America. The records were changed early the next morning and the Associated Press was informed that Santiago had been affected about 30 minutes before they had the news from their own sources.